Australian utility impr Transient Data Manager®

by Pacific Power employees:

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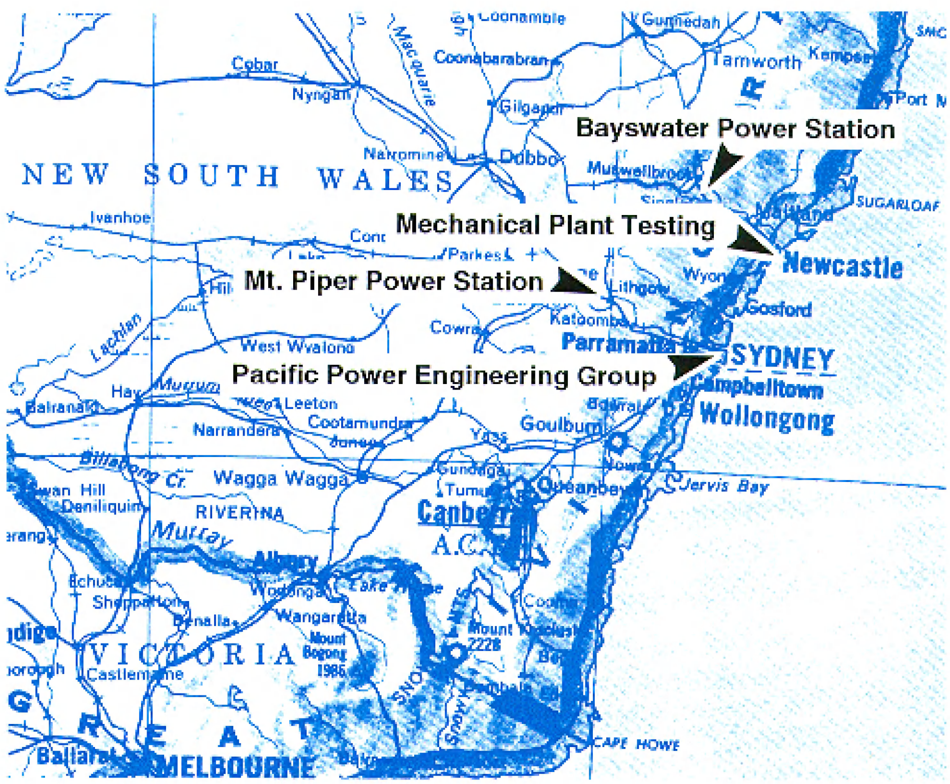
Industry reform is rapidly changing the energy market in Australia, challenging power utilities to operate more efficiently. An important aspect of this challenge is to maximize production from the turbogenerators that are at the heart of electrical power generation. Within Pacific Power, we have responded by changing the way we manage our turbogenerators. This change required us to improve the quality of the vibration information that we base our decisions on. The online monitoring systems we have installed, including the Bently Nevada Engineer Assist™ expert system, have enabled us to implement a Condition Dependent Maintenance program that has improved the performance of our power plants.

Background

Pacific Power is the trading name for the Electricity Commission of New South Wales, in southeastern Australia. Pacific Power, Australia's largest electrical producer, owns and operates seven major coal-fired power stations in New South Wales State, with a total capacity of approximately 12,000 MW. Pacific Power's Power Engineering Group provides engineering and technical services to both internal and external power station customers. The Power Engineering Group's Turbine and CW Systems Branch is located in Sydney, and its Mechanical Plant Testing (MPT) Section is located in Newcastle, 160 km (100 miles) north of Sydney.

The Power Engineering Group supports the operation of the Bayswater and Mt. Piper Power Stations. Bayswater is located 240 km (150 miles) northwest of Sydney, and Mt. Piper is located 120 km (75 miles) west of Sydney (see map). Bayswater Power Station has four 660 MW turbogenerators, and Mt. Piper has two.



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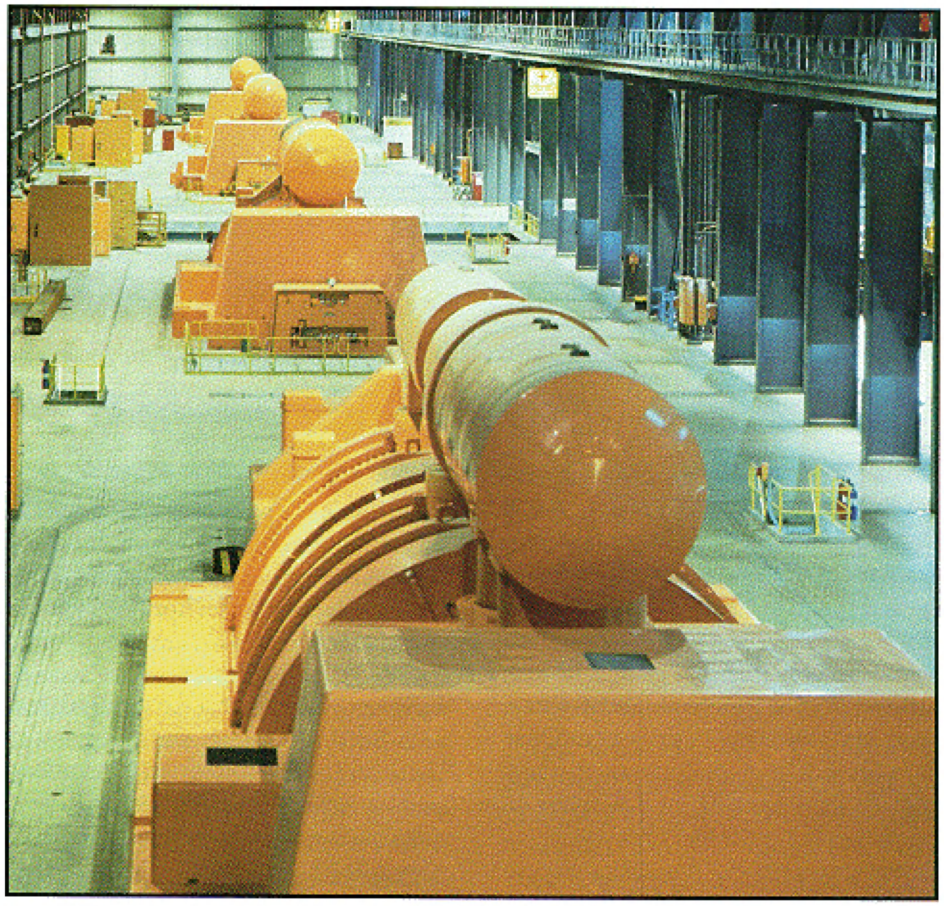
The turbogenerator OEM originally fitted each of the turbogenerators' 10 bearings with single vibration detectors, as part of a Turbine Supervisory Equipment package. The detectors' signals are used for unit runup, general annunciation, computer alarms, vibration indication for plant operators and a conditional unit trip on high vibration. We consider it adequate for unit protection, but not capable of providing sufficient information for a condition dependent operation and maintenance strategy that relies on continuous vibration monitoring and diagnosis.

For this reason, in 1989 we began to retrofit every 660 MW turbogenerator with a Keyphasor® probe, and XY proximity probes on every bearing. We hoped to provide the basis for future purchases of analysis and expert systems, which, at that time, were in an early stage of development.

Prior to the installation of online monitoring at Bayswater and Mt. Piper, machinery at both plants was monitored with a portable Bently Nevada ADRE® III System that used 108 DAIs (Data Acquisition Instrument). This required operators from MPT to travel from Newcastle to each of the plants. Each visit to Bayswater consumed two hours driving time each way, and each visit to Mt. Piper, four hours each way. This was both time-consuming and expensive.

Condition Dependent Maintenance

In the last few years, Pacific Power has focused on improving the asset management of its operational plants, to best operate and maintain the turbogenerators in a safe condition over their economic life. The strategy we adopted is based on Condition Dependent Maintenance. Under this concept, machine condition is closely monitored to allow improved maintenance planning and to reduce maintenance downtime and costs. Condition Dependent Maintenance requires continuous and in-depth awareness of each machine's condition. With this in mind, Pacific Power began investigating turbogenerator condition monitoring systems.



Turbine deck at one of Pacific Power's facilities

Bayswater Power Station near Sydney, New South Wales, Australia

Bayswater and Mt. Piper requested that Turbine and CW Systems research online monitoring and expert systems. Turbine and CW Systems' research showed that these systems have significant advantages over other systems. Online systems increase plant availability through early problem detection and diagnosis, and allow better operational management and maintenance planning. Pacific Power found a number of companies selling online vibration monitoring systems, and a few selling expert systems. Pacific Power drew up specifications, and we invited companies to bid individually on the Bayswater and Mt. Piper projects. Pacific Power selected Bently Nevada systems for both plants. We felt that Bently Nevada's expert system, Engineer Assist, combined with Bently Nevada's unique approach to vibration monitoring and connectivity, best met our needs.

Pacific Power's online system

The Bently Nevada online monitoring, diagnostic and expert systems were commissioned at Bayswater in June, 1993 and at Mt. Piper in April, 1994. Both installations are similar. Each uses Bently Nevada 3300 Series proximity transducers, in an XY configuration, on each bearing of each turbogenerator. These probes are connected to 3300 System Vibration Monitor racks that provide continuous monitoring.

The 3300 racks are connected to Transient Data Manager® External (TDIX) Communications Processors that continually acquire and process vibration data from the 3300 racks. Process variable data, such as electrical output and bearing and oil temperatures, is collected by Bently Nevada Process Data Manager® (PDM) Communications Processors. The TDIXs and PDMs are connected to a Transient Data Manager® 2 (TDM2) computer system that continually monitors and trends turbogenerator vibration and process data during startups, shutdowns and during steady-state operation. The TDM2 system can also plot data in several powerful formats that make machinery diagnostics easier and more accurate.

At both plants, a Bently Nevada Engineer Assist expert system acquires and reduces data from the TDM2 computers. At Bayswater, Engineer Assist Online is installed, which enables the expert system to automatically gather data and perform machinery audits via a network link to one or more TDM2 computers. At Mt. Piper, TDM2 data must be transferred to the Engineer Assist computer via Pacific Power's network when audits are desired. Mt. Piper will soon upgrade to Engineer Assist Online. MPT, in Newcastle, and Turbine and CW Systems, in Sydney, each have a copy of TDM2 and Engineer Assist Software, so they can

Mt. Piper Power Station, West of Sydney, Australia

perform machinery audits and diagnostics remotely, via modem.

Engineer Assist is an expert system that converts the voluminous data collected by a TDM2 computer to "actionable information." According to very detailed rules, it converts vibration data into easy-to-understand diagnostic reports. These reports contain actionable information that tells the plant manager the operational and maintenance options available to him. The diagnostic rules Engineer Assist uses have been adapted from methodologies for diagnosing machine problems that were developed by the Bently Rotor Dynamics Research Corporation. These methodologies have been field-proven for 40 years by Bently Nevada Machinery Diagnostic Services engineers who have used them to diagnose machine problems around the world.

Engineer Assist's reports can be generated on demand, or, if the Online option is installed, automatically, at scheduled times or when a vibration alarm occurs. Engineer Assist Online differs from Engineer Assist only in its method of acquiring data. Engineer Assist Online is connected by a network to the TDM2 computer, which provides its data automatically when audits are performed. Without the Online option, TDM2 data must be copied to the Engineer Assist computer when an audit is desired. With either system, the user is never required to manually enter vibration data; this is a serious shortcoming of other expert systems that can lead to errors.

MPT's experience with Engineer Assist

Because our installations are new, our experience with them is limited. However, we have already reduced our data collection costs, and have tested Engineer Assist's ability to diagnose machine problems. The confidence we have gained in the system has enabled us to change the way we work, to approach problems from a higher, more informed perspective.

The Mechanical Plant Testing group provides a good example of how the TDM2 and Engineer Assist systems have permitted us to operate more efficiently. They have reduced the need for, and thus the cost of, manual data collection, while increasing both the quality and quantity of data available. By freeing vibration consultants from the time-consuming task of data collection, these systems allow them more time for value-added diagnostic services. MPT uses the remote communication facilities of both TDM2 and Engineer Assist to investigate machine faults without travelling from

the office in Newcastle. Each time analysis is required, four hours of travel time to Bayswater is saved, and eight hours of travel time to Mt. Piper.

MPT has also found Engineer Assist valuable as a teaching tool. Its reports contain excellent descriptions of vibration-related machine faults and their associated symptoms. Because many of MPT's personnel have attended Bently Nevada Machinery Diagnostic Training Courses, they are already familiar with the methodologies used by Engineer Assist. Reading Engineer Assist's reports helps sharpen MPT Vibration Specialists' skills, and teaches those unfamiliar with the methodologies how to efficiently and effectively approach vibration diagnostics.

Bayswater tests Engineer Assist

Pacific Power's 660 MW turbogenerators, installed in the late 1970's and 1980's, have IP rotors of nearly identical design. Since commissioning, a number of these IP rotors have displayed a gradual increase in their synchronous vibration amplitude through the first balance resonance, which in some cases has required rotor balancing to rectify. MPT, along with Bayswater and PPE personnel, have been closely monitoring the IP rotors, using permanently installed Bently Nevada XY proximity probes. We have trended the following parameters on each turbogenerator:

- 1X vibration amplitude and phase at the first balance resonance.
- IP Bearing (Bearings 3 and 4) slow roll runout.
- Rotor mid-span slow roll runout, using a temporarily-mounted proximity probe.

During 1993, MPT, using portable Bently Nevada 108 DAIs, detected an increase in both running speed and first balance resonance vibration on the IP turbine bearings on Bayswater's Unit #2. The levels detected, although higher than desirable, were still within limits, and due to operational constraints, it was not possible to carry out corrective action.

Since then, Bayswater's new TDM2 and Engineer Assist systems have given us new power to investigate this problem. For the first time, we can apply continuous online monitoring, trending, and automatic data capture on startups and shutdowns, to our investigations of the vibration state of these IP rotors.

From January 1994 onward, we used the TDM2 System to automatically record most of the startups and shutdowns on Unit #2. Trends of this data showed MPT that IP 1X vibration amplitude at the first balance resonance was gradually increasing. Between December, 1993 and October, 1994, IP first balance resonance vibration at Bearing 4's X transducer increased from 110 μm pp at 135°f to 145 μm pp at 150°, with only a small increase in running speed vibration. The slow roll runout at Bearing 4 also increased slightly, to 37 μm pp at 342°. To obtain further data, we conducted an IP mid-span rotor runout test in October, 1994. Although we detected no increase in midspan bow, we measured a runout of 37 μm pp at 67°.

To assess the capabilities of the recently installed Engineer Assist System and to confirm its diagnoses, we conducted a series of Engineer Assist audits. We compared Engineer Assist audits of different turbogenerators with what we knew about the state of those machines. For Bayswater's Unit #2, Engineer Assist correctly identified moderate IP synchronous vibration and slow-roll runout

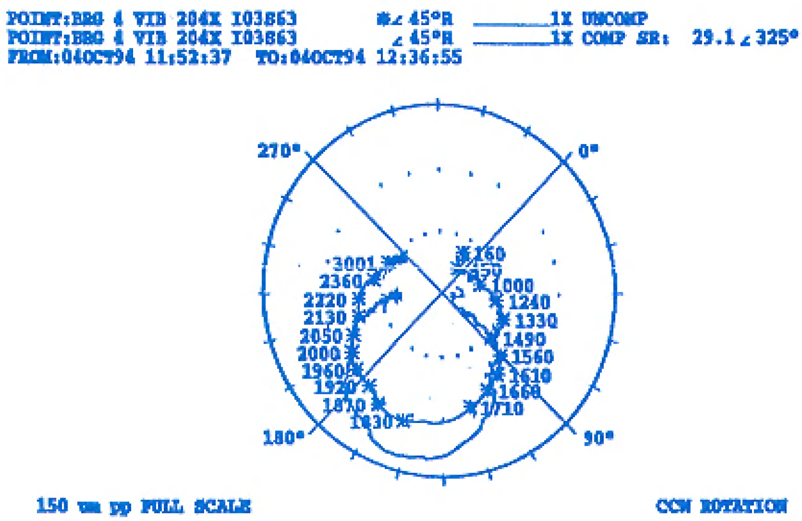


Figure 1:
Polar plot of Bearing 4 rundown, prior to balancing. Full-scale amplitude is 150 μm pp.

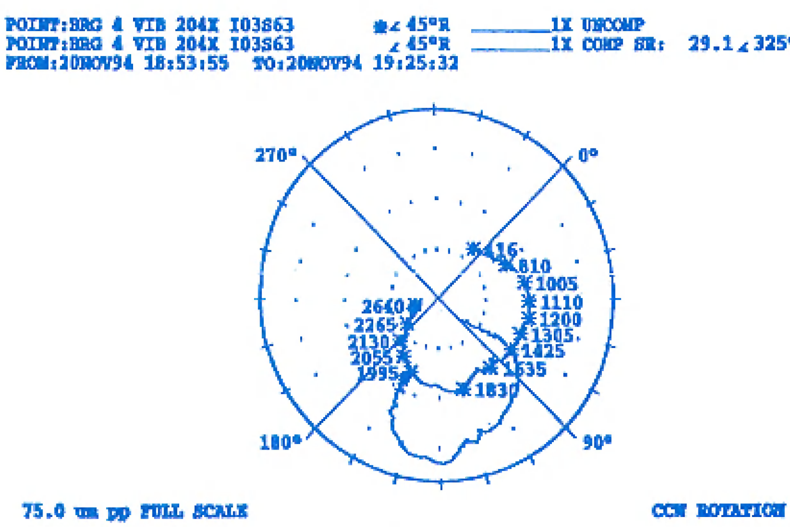


Figure 2:
Polar plot of Bearing 4 startup, after balancing. Full-scale amplitude is 75 μm pp.

on Bearing 4. Engineer Assist suggested that the moderate IP synchronous vibration might be caused by rotor unbalance, while the high runout could be a result of rotor bowing.

From the trend plots we generated for Unit #2, it was apparent that, if left unchecked, the amplitude at the first balance resonance of the IP turbine could reach unacceptably high levels. Because of the forewarning given by TDM2 and Engineer Assist, we decided to trim balance the IP rotor, to reduce its first balance resonance vibration (and, if possible, running speed vibration), during the next scheduled outage.

We used Unit #2 rundown data (Figure 1), captured automatically by the TDM2 System, and influence vectors calculated from similar IP rotors, as inputs to Bently Nevada's Multi-plane Balancing Software. The Multi-plane Balancing Software then suggested an optimum weight configuration to balance this rotor, which we installed.

After balancing, we used TDM2 to record runup data for Unit #2. From this "one-shot" balancing, the IP first balance resonance vibration at Bearing 4 was reduced to 67 μm pp at 135°, and running speed vibration was also reduced (Figure 2). Note the change in polar plot scales between Figures 1 and 2.

We continued to monitor Unit #2 as the machine was loaded. At near full load, we saw indications of fluid-induced instability on Bearing 4, as indicated by the near 0.5X vibration on the spectrum and orbit/timebase plots (Figures 3 and 4). From previous measurements, we had determined that this subsynchronous component occurred at a frequency of approximately 47% of running speed. During the course of the following week, as the machine heat soaked and reached an operating alignment state, the near subsynchronous vibration level fell, to an acceptable level twelve days after startup. The Direct and Not 1X vibration levels decreased from 80 μm pp and 40 μm pp to 48 μm pp and 24 μm pp, respectively.

MPT has found that TDM2's ability to continue monitoring the machine after runups is invaluable in investigating problems which are related to changes in load and temperature.

Future Plans

Bayswater is currently expanding the system to monitor eight steam-feed pumps. This will allow more cost-effective and comprehensive monitoring of known problems. In the future, we plan to integrate TDM2 information into an operators' information system, so we can react quickly and intelligently to changes in plant condition.

Conclusion

The TDM2 and Engineer Assist systems have allowed Pacific Power to better diagnose machine faults and to trend the rate at which machines deteriorate. Therefore, MPT's role has expanded from one of data collection and offline investigation to continuous machine condition monitoring. Because fewer vibration specialists are required to collect data, this higher level of plant monitoring is cost-effective. Moving data and not people, clearly means lower specialist support costs. At Pacific Power, our investment in TDM2 & Engineer Assist is proving to be a key factor in our Condition Dependent Maintenance program. ■

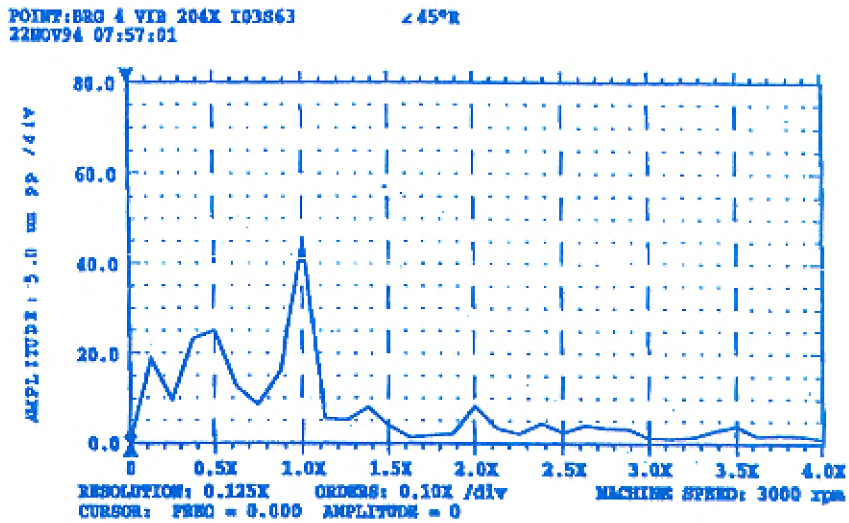


Figure 3:
Bearing 4 spectrum plot, two days after return to service.

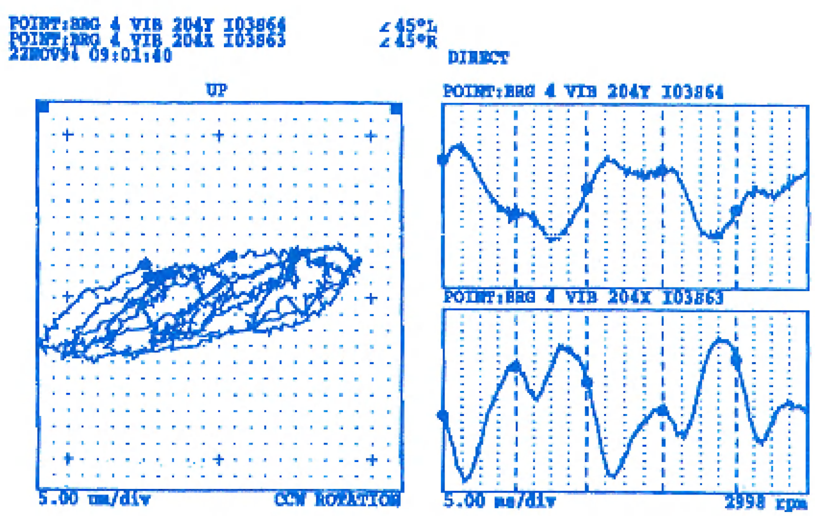


Figure 4:
Bearing 4 orbit/timebase plot, two days after return to service.